Study on containerisation of irradiated fuel at JRC ISPRA for medium/long-term storage

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Abstract

During the last 40 years big amounts of wastes arising from past experiments have been generated at JRC Ispra. These wastes are now stored on site in unconditioned form and must be characterised and re-conditioned to ensure their acceptance by future repositories.

Among the several types of wastes produced, spent fuel has a great importance in JRC waste management. In fact, there are more than ten tons of irradiated material, varying widely from commercial to experimental fuel elements or pins, in form of oxides and metal fuel, with very different geometry, dry and wet stored. The biggest part of it can be considered as "unirradiated", according to the IAEA regulations (ST-1, 1996), while a relatively small amount (nearly 720 kg U total) are to be considered as irradiated and treated accordingly.

Studies on the most suitable solutions for medium/long term storage for such irradiated experimental fuel are being performed, taking into account two main options: containerisation of the nuclear material, as it is, in suitable casks or reprocessing.

The technical aspects of the project for containerisation are here discussed.

KEYWORDS: liabilities, wastes, waste management, spent fuel, irradiated fuel, containerisation, cask, reprocessing, fuel handling.

1. Historical and future liabilities and status of nuclear installations at JRC ISPRA

The nuclear related liabilities of the European Commission, coming from its nuclear installations at the Joint Research Centres, can be divided in two groups:

HISTORICAL LIABILITIES, resulting from past activities intended to help develop a competitive

European nuclear industry. They include providing appropriate waste management facilities and services, the decommissioning of shutdown nuclear installations and the management of existing and decommissioning-related wastes. Most of historical liabilities are related to the JRC Ispra site.

FUTURE LIABILITIES, covering the decommissioning of nuclear installations still used for research purposes and managing the associated wastes arising.

The management of its nuclear installations, as envisaged by Article 8 of the Euratom Treaty (1957), renders the Commission responsible of a facility throughout its life until it is de-licensed. Therefore, in keeping with applicable national and European legislation, the JRC is required to decommission its shutdown nuclear installations and manage the associated radioactive wastes. For this reason the European Commission has developed a Decommissioning & Waste Management (D&WM) Program, which foresees the progressive elimination of its historical liabilities throughout the next two decades.

The JRC's D&WM long term action plan has been elaborated in co-operation with a group of external experts and is divided into three parts:

1. **Management of wastes resulting from JRC activities since 1960 (Historical liabilities).**

   This phase also includes a number of generic activities:

   - the safe conservation of shutdown (and obsolete) installations;
   - removal of nuclear and special materials, which could delay the start of the decommissioning, from facilities;
   - investments in appropriate waste management facilities and services;
   - managing (manipulation, decontamination, treatment, containerisation and storage) of existing solid and liquid wastes and clearing old waste stores;

2. **Decommissioning of shutdown facilities**, such as reactors and laboratories

3. **Evaluation of resources necessary for future dismantling** of nuclear facilities still in operation.

   The list of nuclear installations to be decommissioned includes:

   - *Safe Conservation shutdown installations*: ESSOR nuclear reactor, Ispra1 reactor, Hot Laboratory for R&D.
   - *Installations planned for out-of-service in few years*: STRRL, Radiochemical Laboratory, Dry Storage facility for spent fuel (dry pits).
   - *Installations, which will come to the end of their operational life*: Cyclotron, FARO facility.
   - *Other facilities, which will become obsolete during the progress of the decommissioning general program*: Storage and treatment areas.

2. Inventory of JRC ISPRA experimental irradiated fuel

During four decades of research at the JRC Ispra site, a variety of irradiated nuclear material, which no longer serve current scientific and technological activities, has been accumulated. The overall inventory of the experimental irradiated fuel, summarised in Table 1, consists on assemblies, individual rods, fragments of rods and test rigs, typically fabricated from natural uranium or low enriched uranium, irradiated at several burn-ups in ESSOR and ISPRA1 reactors as well as in other European power reactors. The material is stored in several on-site locations:

Table 1

Irradiated fuel ID	Location	N. Container	Physical form of fuel	N. Items	Elementary Dimensions L(mm) x D(mm)	Fresh fuel Enrichment (%)	Burn-up (MWd/kg)	*Year of discharge*	*Total amount per irradiated fuel ID*	U total (kg)	U 235 (g)	Pu total (g)
CART	Pond	2 test rigs DEMAG	fuel bundles	6	500 x 150	UO2 - natural	0 - 3,7	1983		124.00	396	
	ADECO dry pit N.1-N.4	3 basket(1); 1 B(4)	fuel bundles	5	500 x 150	UO2 - natural	0 - 3,7	1983		95.46	305	
	ADECO ch.à aig.	1 Chateau aiguill.	fuel bundle/rods	1/30	500 x 150	UO2 - natural	0 - 3,7	1983		57.16	183	
	Bld39 dry pits B/2,C/2,C/1,B/3	5 pots à aiguilles	rods(fragments)	201	500 x 150	UO2 - natural	0 - 3,7	1983		232.80	744	
									CART	**509.42**	**1628**	**128**
Exotic Material												
GIOCONDA	Pond	4 DEMAG	test rigs	4	150 x 15	UO2 - natural	4,75 - 5,6		1978-1982	0.51	1	
COLIBRI'	Pond	no container	capsules	4	20,8 x 19,6	UO2 - 10,5 / 93	26	1975		0.01	2	
SUPERSARA	ADECO 4301	CSC2 - B46	rods	60	2071 x 9,5	UO2 - 3,2 / 6,4	0	1983		54.44	2526	
									Exotic material	**54.96**	**2529**	
Reactors												
TRINO V	Pond	1 Basket	rods	12	3220 x 10	UO2 - 3,9	28.7	1973		17.56	316	
	Bld39 dry pit C/2, D/1	1 pot à aiguilles, 1 basket	rods(fragments)	4	3220 x 10	UO2 - 3,9	28.7	1973		5.85	81	
	ADECO dry pit N.3	1 F	rods(fragments)	n.a.	3220 x 10	UO2 - 3,9	28.7	1973		0.05	1	
									TRINO VERCELLESE	**23.46**	**398**	**206**
OBRIGHEIM	Pond	1 Basket	rods	6	2916 x 10,75	UO2 - 3,2	32.4	1974		8.81	74	
	ADECO dry pit N.2-N.4-N.5	1 C(2),1 D(2),1 B(4),1 basket(5)	rods(fragments)	10	2916 x 10,75	UO2 - 3,2	32.4	1974		6.12	51	
	Bld39 dry pit D/2	1 pot à aiguilles	rods(fragments)	6	2916 x 10,75	UO2 - 3,2	32.4	1974		7.61	67	
									OBRIGHEIM	**22.54**	**192**	**160**
WUERGASSEN	Pond	1 basket	rods	9	4140 x 14,75	UO2 - 1,1 / 2,5	23.6	1979		34.11	181	
	ADECO dry pit N.2-N.4-N.5	1 C(2),1 B(4),1 E(4),1 basket(5)	rods/pellets	8	4140 x 14,75	UO2 - 1,1 / 2,5	23.6	1979		22.70	118	
									WUERGASSEN	**56.81**	**299**	**435**
GUNDREMMINGEN	ADECO dry pit N.4-N.8	390XM(4); 393XM(8)	rods(fragments)	5	3555 x 14,28	UO2 - 2,55	17 - 22,6	1974		16.46	148	
	Bld39 dry pit D/2	1 pot à aiguilles	rods(fragments)	5	3555 x 14,28	UO2 - 2,55	17 - 22,6	1974		14.19	125	
									GUNDREMMINGEN	**30.65**	**273**	**215**
GARIGLIANO	ADECO dry pit N.3	A	rods(fragments)	4	2718 x 15,06	UO2 - 1,779	27*	1975		6.16	112	
	Bld39 dry pit C/2	1 pot à aiguilles	rods(fragments)	4	2718 x 15,06	UO2 - 1,779	27*	1975		6.40	114	
									GARIGLIANO	**12.56**	**226**	**42**
Other experiments												
DICOM 02	Bld39 dry pit C/2	1 pot à aiguilles	rods	n.a.	257 x 40	UO2-Mo/UO2-W alloy- 21.55	n.a.	1975		0.05	12	
RIG FPR03-04	Bld39 dry pit C/2	1 pot à aiguilles	rods(fragments)	n.a.	n.a.	UO2 - 9	n.a.	1975		0.05	5	
RIG FPR02-05-06	Bld39 dry pit C/2	1 pot à aiguilles	rods(fragments)	n.a.	n.a.	UO2 - 9.5	n.a.	1975		0.08	7	
									Other experiments	**0.18**	**24**	**0**
									TOTAL AMOUNT	**710.57**	**5569**	**1186**

- The pond in ADECO (Atelier pour le Démantèlement des Elements de Combustible) laboratory
- The dry pits in the ADECO working cell
- The dry pits in an underground storage area
- Storage areas in ESSOR reactor building.

Table 1 contains, among others, some complementary information, as follows:

- *Overall dimensions*: refer to the total length and maximum diameter of each container, element or other forms of the irradiated fuel;
- *Elementary dimensions*: refer to the dimensions of the single items (rod, assembly);
- *Container quantity*: is the number of containers of a certain type;
- *Element ID*: refer to the fuel type contained in the packages presently stored at JRC Ispra;
- *Location*: refer to the present location of the irradiated fuel in the storage areas at JRC Ispra;
- *Information on fuel type, burn-up and amounts of material* (element and isotopes).

3. Options for the recovery and safe storage of JRC ISPRA experimental irradiated fuel

The JRC Ispra, in the frame of activities related to Chapter 1, has outlined, as a project with very high priority, the recovery and safe storage of its experimental irradiated fuel. While the rapid transfer from site of such material is the most desirable outcome for the JRC Ispra, discussions with the nuclear industry representatives indicate that two different alternatives are possible:

3.1. Containerisation of the material in suitable casks

The containerisation, using ad-hoc dual purpose transport/storage casks, will be performed in a manner suitable for the material's on-site storage, effectively as conditioned waste in the future interim store, and for its eventual transfer to and storage in the surface based repository. The planned Italian nuclear waste repository will include a section for safe (temporary) storage of irradiated fuel, in casks or in a conditioned form.

The main envisaged advantages of this solution are:

- Containerisation is "relatively easy" from the engineering point of view;
- Overall costs do not include the reprocessing costs and any eventual additional costs induced by reprocessing (transport, temporary storage at reprocessor premises);
- Feasibility studies already done, so that the time schedule for this solution is shorter than for reprocessing;
- This is in line with a growing number of countries that no longer reprocess spent fuel.

The main disadvantage of this solution is assumed to be the relatively big volume occupied by casks and, consequently, the room required to store them in the interim store and in the final repository. Assuming that the repository costs are rapidly increasing with volumes of wastes stored, further investigations on the basis of a cost-benefit analysis are necessary.

3.2. Reprocessing

The main envisaged advantages coming from reprocessing are:

- Wastes already conditioned and ready for transfer to the interim store and/or repository;
- Reduced volumes of wastes, if compared with containerisation.

Among the principal disadvantages, it can be mentioned that costs of reprocessing itself and transport of the fuel may be very high given the **material's diversity** and, from a reprocessing plant viewpoint, **limited quantity**. Also the variable quality of the fuel to be reprocessed plays a negative role.

From first contacts with reprocessing companies, also fuel characterisation, general **handling activities** and preparation of the material for its shipment to the reprocessing plant is a major problem.

The JRC Ispra is currently assessing the feasibility of the containerisation of its spent fuel in casks suitable for locating as Category 3 waste in the interim store, and, in the long-term, for the transport to and storage in Italy's repository.

Notwithstanding this assessment, JRC Ispra has not excluded the possibility of reprocessing the irradiated fuel if it can be technically and economically justified. With respect to this, JRC Ispra has launched a project for the reprocessing of its spent fuel and contacts with two world-leading European companies have been taken to carry out such a project.

4. The Project of Spent Fuel containerisation in casks

This project, entailing the containerisation of the inventory listed in Table 1, has been developed in two phases:

a) The first phase is a contract covering a **feasibility study**, whose scope is the collection of the relevant data to allow the JRC Ispra to finalise the whole project plan and prepare the call for tender technical specifications for the design, realisation and provision of the dual purpose storage-transport cask and its loading with the irradiated nuclear material.

b) The second (and principal) phase is a two-stage contract, which will entail the execution of the technical specifications.

Some peripheral activities have still to be performed before the execution of the principal contract:

- Assimilate the irradiated fuel's existing life-records and characterise the irradiated fuel in accordance with the Italian regulation;
- Transfer, as an intermediate step, the irradiated fuel assemblies presently stored in the dry pits in the underground storage area to the ADECO hot cells. This project must be completed well in advance of the scheduled loading of the casks with the irradiated fuel.
- Remove the NaK coolant, in which high burn-up fuel pellets are still immersed, from the four Gioconda rigs.

Stage a. has been already accomplished and finalised by means of the execution of the relevant studies mainly focusing on:

- Fuel handling;
- Choice of casks and inner disposition of the spent fuel.

Handling and packaging constraints, required resources, new equipment, minimisation of radiation doses to the personnel, costs and timing have been considered as major variables.

The outcome of phase a., which will be briefly discussed hereafter, is an operational solution to be considered as a mandatory input for stage b.

4.1. Fuel handling constraints

The fuel handling constraints to face with are the *existing buildings, the civil structures and the operational equipment*. With the aim to keep costs as low as possible, no modifications to the existing buildings and structures are envisaged, while the upgrading of the existing equipment and its implementation with new one are expected.

There are basically two available rooms for fuel handling, manipulation and preparation:

- ESSOR storage pond;
- ADECO laboratory, including the working hot cell and the auxiliary cell;
- Dry pits in underground store

4.1.1. ESSOR storage pond

The pond has two communicating sections: one where the fuel is stored and another one available for handling operations.

A two-tackle crane with capacity of 40 Mg and 6 Mg respectively is available. A bridge is also available for operators to manipulate nuclear fuel with specific tools. The area is accessible by truck.

A rotating arm is situated underwater between the pond and the working cell. With its assistance, single fuel rods and test rigs can be transferred from the pond to cell, where the fuel will be handled and introduced into the cask using suitable equipment.

4.1.2. ADECO Cells

The working cell is connected to the ESSOR storage pond and includes a 2 Mg capacity crane, used for transportation procedures inside the cell, and between this and the auxiliary cell at lower level. The maximum height of the hook is 5320 mm. Other equipment available are a manipulator "SERI2300" with maximum capacity of 300 kg in all positions and two manipulators CRL mod: "F" for each window, with capacity of 10 kg each, carrying a hanging load up to 40 kg. The working cell is also equipped with an existing opening (diameter 645 mm), previously suitable to receive a TN7-type cask and is connected by a vertical passage to the lower auxiliary cell, equipped with a crane of 1000 kg capacity (maximum height of hook is 2440 mm) and manipulators.

The ADECO laboratory, in which the two cells are located, is equipped with a ventilation system, which will be utilised to dry the fuel assemblies, rigs and rods coming from the pond.

Both cells are in communication with a rear room, which is quite large and equipped with a 20 Mg crane. The adjacent room is accessible by truck and is included in the operating area of the crane.

4.1.3. Dry pits in underground storage area

This is a dry pit storage area containing special fissile material and irradiated fuel in sealed canisters, called "pot à aiguilles". Each pit is covered with a steel plug, whose cavity is filled with concrete ensuring the necessary shielding. The irradiated fuel confined in special lead canisters, called "pot à aiguilles". These are equipped with a clamping head and are centred in the wells by means of positioning baskets.

The area is equipped with a 30 Mg bridge crane foreseen to lift the plugs and the auxiliary equipment, called "chateau à aiguilles", especially designed to accommodate and transport one pot à aiguilles.

4.2. Packaging constraints

The experimental irradiated fuel shall be retrieved from the present storage places and loaded into dual purpose casks considering the following constraints:

- Since the hot cells are presently in clean condition (very low radioactive contamination), it is considered to handle the irradiated fuel stored in the dry pits without damaging its containment barrier. This will avoid the spread of contamination that would require a heavy work for subsequent decontamination of the cells and other handling equipment. This means also that the irradiated fuel packages, containing the fuel in different forms even bulk, will be handled as they are found in the storage places and no opening of the container is envisaged. If they are stored in dry condition, they must be drying transferred to the cask-loading place, because their containment is not tight guaranteed.

- The so-called "pot à aiguilles, stored within the dry pits in the underground store, could require to be opened, in order to check for the presence of ground water. After internal inspection, they will be closed again without any intervention on their content. This operation shall be performed in the working cell that will be properly equipped according to the needs.
- The transfer of the irradiated fuel, presently stored in the pond, to the working cell shall take into account the maximum allowed diameter, according to the dimension of the connection between the cell and the pond. This means that the baskets holding the fuel rods in the storage place of the pond do not comply with and the fuel rods must be individually transferred to the working cell.
- The irradiated fuel rods, presently stored in the pond, shall be preferably loaded into the cask avoiding their cutting in short pieces. This will prevent from heavy radioactive contamination of the cells, implying a time consuming decontamination of structures and equipment and the production of additional radioactive waste that must be treated and disposed of. However, cutting operation to reduce pin length has been considered as second priority option.
- The irradiated active portion of the test rigs is much shorter than the overall length of the rig itself. In such case the cutting of that portion is foreseen, in order to save room inside the cask. It is expected that only small amounts of additional radwastes will be generated, if the cutting is beyond the active part of the rig.
- The dual-purpose cask shall have a total weight, when loaded with the irradiated fuel, complying with handling equipment capacity of Ispra site, as indicated before.
- The cask geometry shall fit the actual configuration of the building structures, in order to limit at the minimum extent the impact to the civil work of Ispra site.
- The cask shall be provided with internal baskets, so that the irradiated fuel will be firmly held in the correct position during every step of its handling, interim storage, transportation and eventual storage of the cask at the final repository.

4.3. Fuel handling

Among the various possible processes for the safe handling of the experimental irradiated fuel and its packaging and loading into a cask, the dry re-loading **inside the working cell** has been retained as the most suitable solution. The constraints listed in par. 4.1 and 4.2, limitations on personnel exposure to radiation and overall costs played a decisive role on this choice.

Other possible solutions, like wet reloading in the pond or dry reloading outside the cell, have been rejected because of high costs, mainly due to the purchase of new additional and expensive equipment (flasks, shields, etc.), high doses to the personnel and, in some instances, handling procedures not compatible with the existing site characteristics.

The chosen solution starts from the basic assumption that the fuel, which has to be adequately prepared for its loading and accommodation into the dual purpose casks, must be transferred from its current location to the working cell, **as a mandatory step for all handling activities to be performed**. This is due to the fact that only this cell has suitable licence, dimensions and equipment to operate, as it was already done in the past, on spent fuel.

4.3.1. Fuel handling procedures

4.3.1.1. Loading position of the casks

The loading position of the cask, situated beside the working cell in correspondence of the existing opening, will be reached with the assistance of the 20 Mg crane. The casks will be coupled to the existing hatch foreseen for material entrance, 645 mm useful diameter, by means of the existing equipment.

4.3.1.2. Transport vehicle access

The transport vehicle, carrying the empty cask, will enter the ADECO lab and will reach the zone of operation of the bridge crane. The cask is lifted by the crane and horizontally positioned on the floor, at level +2,70 m, with the top opening close to the round shaped opening of the cell. This opening has an external removable protection and can be internally unlocked by means of the handling equipment already installed inside the cell.

4.3.1.3. Irradiated fuel retrieval

Pond

The irradiated fuel, wet stored in the pond, has three configurations:

- Fuel rods stored in baskets;
- Fuel elements in test rig.
- Experimental fuel elements, PWR type, in aluminium containers.

The fuel rods (PWR, BWR type) are placed in baskets. By means of the cantilever crane the single fuel rods will be extracted from the basket and one at a time brought to the rotating arm for their transfer into the cell. Here they will be handled with the assistance of the manipulators and the crane and re-packed in a new basket, whose dimensions shall be optimised to properly fit the cask together with the other fuel containers.

The test rigs (GIOCONDA, COLIBRI and CART) will be transferred into the cell by means of operational equipment.

As the total length of the rigs does not allow their loading into the casks, they must be cut in order to reduce their length. This is possible because the section containing fissile material is only a small portion of the total length of the rig. The cutting of test rigs has also the additional effect to save load capacity in the cask.

The cutting of test rigs can be done either in the pond or in the cell. From a radiological protection point of view the second solution is considered the most desirable.
In the cell it is foreseen the proper re-packaging of the active section in suitable container, which will be loaded into the cask.

The SUPER SARA fuel elements are stored in aluminium containers. Because of their low contact dose rate (40 microSv/h), they can be handled without additional shielding and transferred to the working cell through the auxiliary cell.

Containers in dry pits of the working cell

Aluminium containers with several types of fuel rods are located in the dry pits inside the cell. With the assistance of the manipulators the containers will be gripped, removed from the pit and then loaded directly into the internal basket of the cask by means of the crane in the cell.

Pot à aiguilles in dry pits

Regarding the so-called "pot à aiguilles" presently stored in the underground storage area, a transfer campaign is planned in order to move them to the ADECO lab. The transfer will utilise the "chateau à aiguilles" carried by truck, whose access to the ADECO lab is in agreement with the existing procedure. Here the containers will be stored in an ad hoc deposit rack by means of the hoist gear of the chateau à aiguilles.

Later on, the pot à aiguilles, in the number to be loaded in the cask, will be transferred to the working cell through the available opening.

4.4. Dual purpose cask selection criteria

Based on the above considerations, the choice of the dual purpose cask will be affected by the actual length of the longest fuel rods, whilst the remaining irradiated fuel shall be packaged or arranged in the proper way to fit the cask internal cavity geometry, utilising the available room at the maximum extent. The characteristics of commercially available casks have been investigated to find those ones better complying with the above constraints.

Small size casks, as those used for irradiated MTR fuel, have been considered, since they comply with handling capacity of Ispra site facilities. Nevertheless, they present the following disadvantages:

- The cavity height does not allow the loading of irradiated fuel rods stored in the pond, which should have been cut in short pieces thus generating significant amounts of secondary radwastes and requiring an additional packaging of the cut fuel rods;
- The cask opening size does not allow the loading from the lateral opening of the working cell. They should have been loaded in another room, using additional heavy shielding equipment in order to overcome the potential for significant doses to personnel during the transfer operation.

From this scenario it appears that the MTR type cask is not the suitable solution for the Ispra fuel.

Bigger casks, as those generally used for LWR irradiated fuel, will allow the fuel rod loading without any cut operation and, moreover, present the advantage to have already undertaken a license process for dual purpose application in other countries. In this particular case they cannot be used since:

- They require handling equipment capacities not available at Ispra site;
- A complete cask re-design would be required in order to reduce its size (and weight), thus the advantage to have already a dual-purpose cask license in other countries is wasted.

The result of the investigation leads to conclude that, at present, none of standard design casks available from the market is fully complying with the requirements deriving from handling and packaging constraints of the irradiated fuel of JRC Ispra.

A dual purpose cask, small diameter and quite long, is the envisaged solution provided that its maximum weight is not far exceeding the bridge crane capacity and/or the crane design has enough margin to allow the crane upgrading according to the new demand.

It should be considered that, from the licensing point of view, a dual-purpose cask has to meet both the requirements of storage and transport cask:

As a *transport cask*, it should have a transport license, based on fuel characteristics and arrangement, to allow the shipment of the irradiated fuel from one site to another one.

As a *storage cask*, it has to undertake a license process, which is targeted on safe monitored conditions.

4.4.1. Cask internal baskets

The envisaged cask is provided with an internal basket (cask basket), whose geometry fits the irradiated fuel container or assembly to be packaged.

In principle, the cask basket is composed of a number of straight pipes, one aside and parallel to the other, whose dimensions have been defined on the base of the following rationale:

- *length*: it depends on the length of the fuel assembly or container to be housed.
- *diameter* of each basket: it depends on the outer cross dimension of the irradiated fuel containers or assembly where the fuel was packaged.

- *symmetrical arrangement and standardisation of the pipe diameters and lengths*, in order to simplify the manufacturing and the eventual criticality evaluation of the fuel arrangement inside the cask.

A particular solution is adopted for the fuel rods, which have to be individually transferred to the cell 4411, where they are loaded first into new baskets, similar to those ones of the storage pond but with smaller diameter.

The new irradiated fuel baskets are then loaded into an individual pipe of the cask basket, whilst other containers or assemblies those are shorter than the fuel rods, even if of different content, may be loaded inside the same pipe, depending on their outer diameter.

Based on this, the irradiated fuel inventory has been grouped and arranged as shown in Figure 1 and Figure 2 and for this two dual-purpose casks are expected to be required.

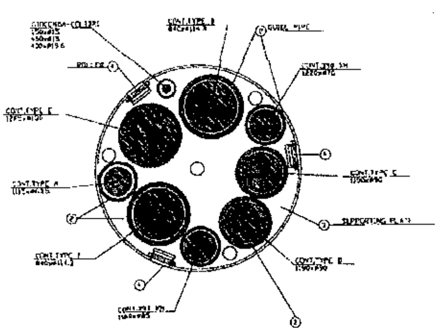
4.5. Irradiated fuel arrangement inside the cask

Based on the irradiated fuel inventory of Table 1 and relying on the reference scenario of handling, the arrangement inside the cask is performed in the way indicated in the following paragraphs.

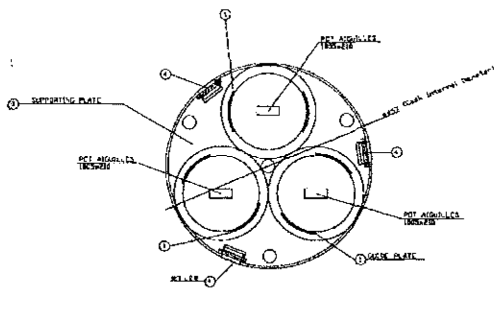
4.5.1. Cask N.1

The cask will be positioned as described at par. 4.3.1 and a three-section cask basket is foreseen to be packaged inside the working cell and eventually loaded into the cask itself.

The lower section of the basket is a frame with supporting plates, guide plates and two guide pipes

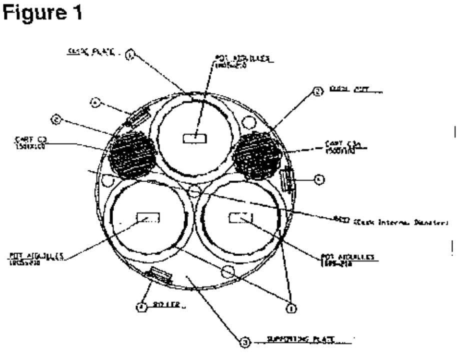


Cask # 1 upper basket section

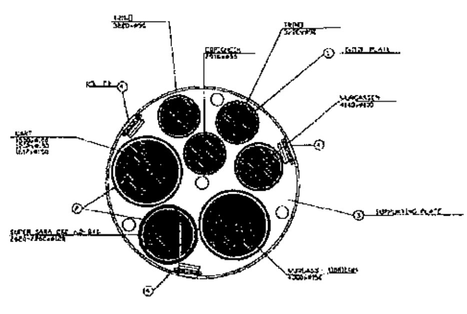


Cask # 1 intermediate basket section

Figure 1



Cask # 1 lower basket section



Cask # 2

Figure 2

having the function of keeping in the proper configuration the irradiated fuel containers.

The intermediate basket section is similar to the lower one, but the two guide pipes are not required because this section is dedicated to three pot à aiguilles only. It will be loaded, as described above for the lower basket section, with three pot à aiguilles and then it will be removed and positioned on the tilting stand to be bolted to the top of the lower basket section.

The upper basket section is a frame with supporting plates and a number of short guide pipes, which can be loaded as described above for the first section. This basket section is positioned and bolted on the top at the intermediate one, the tilting stand is tilted to the horizontal position. Then, the three-section basket is introduced into the cask; the horizontal sliding of the assembly is aided providing each basket section with a number of peripheral rollers.

4.5.2. Cask N.2

The cask, positioned as described at par.4.3.1, will be equipped with an internal basket, mainly constituted by longitudinal guide pipes, and cross support plates. The irradiated fuel will be loaded into the basket, laid on the tilting stand in horizontal position, by means of the mechanical harms of the cell.

The introduction of this basket into the cask is identical to the Cask 1 basket.

5. Cost estimation and time schedule

The cost estimation of all activities concerning engineering, licensing, supply fabrication and test of fuel casks for the reference solution is here indicated:

ACTIVITY	ESTIMATED COST (k€)
Project Management	250
Cask design and licensing	1300
Supply of two casks	2300
Total costs	**3850**

This cost estimation does not include the handling of casks at site and the infrastructure cost for their storage at Ispra site.

The total duration of the project is expected to be about 3 years (more precisely 35 months), supposing that the national Authority shall approve the licensing documentation and give permission to construction six months after the delivery of the relevant documentation.

The cost estimation of new equipment to be supplied is as follows:

ACTIVITY	ESTIMATED COST (k€)
Project Management	350
Design and licensing	550
Supply of equipment	660
Total costs	**1560**

The total duration of the project is expected to be about 28 months.